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Simulation Chamber for Space Environment Survivability Testing

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Space Environment Effects

The space environment can modify materials and cause detrimental effects to satellites. Some of these effects are change in reflectivity and emissivity, which lead to changes in thermal, optical, and charging properties. If these effects are severe enough the spacecraft will not operate as intended.

The key to predicting and mitigating these effects is to have reliable, reproducible, and accurate simulation space environment effects through long-duration, well-characterized testing in an accelerated, versatile laboratory environment.

In Situ Analysis Capability

UVVIS/NIR Reflectivity-Two fiber optic spectrometers (F) measure reflectivity in UVVIS/NIR (200-1080 nm) NIR (858-1700 nm) ranges with <1 nm resolution.

Integrating Sphere-A 2.5 cm diameter integrating sphere (H) can be translated over the samples with a retractable probe linear translation stage (T). The sample stage can be rotated to position different samples under the probes. Light from a deuterium/Halogen calibrated light source enters the integrating sphere through one fiber optic connection; reflected light from the sample exits through another fiber optic to spectrometers.

IR Emissivity-Measured with retractable probe (4 μm to 15 μm) mounted on probe translation stage.

Calibration Standards-in situ high and low reflectivity/ emissivity calibration standards (H) are mounted behind the probe translation stage.

Light Flux-Continuously monitored with in situ photodiodes (I) before and after each sample exposure. Light from a deuterium/Halogen calibrated light source enters the integrating sphere through one fiber optic connection. The sphere maintains 98% uniformity on the sample area. The system allows for measurements to be taken while the samples are still under vacuum and exposed to radiation. With these accurate simulations we can closely predict the material's behavior in near proximity to the sun. This information is vital in determining materials for satellites, probes, and any other spacecraft.

Abstract

A vacuum chamber was designed and built that simulates the space environment making possible the testing of material modification due to exposure of solar radiation. Critical environmental components required include: an ultra high vacuum (10-9 Torr), a UVVIS/NIR solar spectrum source, an electron gun and charge plasma, temperature extremes, and long exposure duration. To simulate the solar spectrum, a solar simulator was attached to the chamber with a range of 200nm to 2000nm. The exposure time can be accelerated by scaling the solar intensity up to four suns. A Krypton lamp imitates the 120 nm ultraviolet hydrogen Lyman alpha emission not produced by the solar simulator. A temperature range from 100k to 450k is achieved using an attached cryogenic reservoir and resistance heaters. An electron flood gun (mono-energetic, 20 eV to 10keV) is calibrated to replicate solar wind at desired distances from the sun. The chamber maintains 98% uniformity of the electron and electromagnetic radiation exposure relative to the center. The chamber allows for a cost-effective investigation of multiple small-scale samples. An automated data acquisition system monitors and records the reflectivity, absorptivity, and emissivity of the samples throughout the test. An integrating sphere and an IR absorptivity/ emissivity probe are used to collect this data. The system allows for measurements to be taken while the samples are still under vacuum and exposed to radiation. With these accurate simulations we can closely predict the material's behavior in near proximity to the sun. This information is vital in determining materials for satellites, probes, and any other spacecraft.

Experimental Test Chamber Design

The vacuum chamber was designed and fabricated to accommodate critical environmental conditions. The chamber is particularly designed to mimic the space environment with stable, uniform, long-duration electron and UVVIS/NIR fluxes at up to 4 times sun equivalent intensities for accelerated testing for a sample area of 3 cm by 8 cm. Particularly well suited for cost-effective tests of multiple small-scale materials samples over prolonged exposure.

Space Environment Characteristics

There are certain characteristics of the space environment that are critical for a true simulation. These critical characteristics are electron flux, electromagnetic radiation, vacuum, and temperature. The electron flux is critical because the solar winds through space bombard spacecraft. The electromagnetic radiation has many critical aspects in itself. As can be seen in figure 10, the electron flux (E) of the chamber is similar to the Visual/Infrared to Ultra-Violet, specifically the Hydrogen Lyman Alpha emission at 121.6 nm. A vacuum is essential to prevent any contamination of the chamber. The temperature is critical because it changes drastically depending on proximity to the sun. Things not covered by this chamber are photons/ions, and atomic oxygen.

Spectral Chamber

Versatile ultrahigh vacuum test chamber provides controlled temperature and vacuum environment with repetitive uniform, long-duration electron and UVVIS/NIR fluxes at up to 4 times sun equivalent intensities for accelerated testing for a sample area of 3 cm by 8 cm. Particularly well suited for cost-effective tests of multiple small-scale materials samples over prolonged exposure.

Acknowledgements/References

[References]

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